US011550243B2

(12) **United States Patent**
Numata et al.

(10) **Patent No.: US 11,550,243 B2**
(45) **Date of Patent: Jan. 10, 2023**

(54) **IMAGE FORMING APPARATUS CONTROLLING RECORDING MEDIUM LOOP**

(71) Applicant: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(72) Inventors: **Yoshiya Numata**, Ibaraki (JP); **Kazuyuki Narita**, Chiba (JP)

(73) Assignee: **Canon Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/460,502**

(22) Filed: **Aug. 30, 2021**

(65) **Prior Publication Data**

US 2022/0100127 A1 Mar. 31, 2022

(30) **Foreign Application Priority Data**

Sep. 28, 2020 (JP) JP2020-162086

(51) **Int. Cl.**
G03G 15/20 (2006.01)
G03G 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/2028*** (2013.01); ***G03G 15/2064*** (2013.01); ***G03G 15/657*** (2013.01); *G03G 2215/2045* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/2028; G03G 15/2064; G03G 2215/2045
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,870,114	A	2/1999	Numata et al.	
6,595,515	B2	7/2003	Numata et al.	
10,712,692	B2 *	7/2020	Kurata	G03G 15/6576
2006/0222394	A1 *	10/2006	Koshida	G03G 15/657 399/68
2017/0227897	A1 *	8/2017	Kaino	G03G 15/2028

FOREIGN PATENT DOCUMENTS

JP	H10-097154	A	4/1998
JP	2003-241453	A	8/2003

* cited by examiner

Primary Examiner — Arlene Heredia
(74) *Attorney, Agent, or Firm* — Venable LLP

(57) **ABSTRACT**

An image forming apparatus includes a control unit that controls a conveyance velocity of conveying a recording medium by a fixing unit, to form a loop in the recording medium between a transfer nip portion and a fixing nip portion, in which the control unit controls the conveyance velocity to decrease the loop when a rear end of the recording medium reaches a first position that is apart upstream, in the conveyance direction, from a conveying nip portion of a conveying unit, by a distance that corresponds to a circumference length of a pressure-applying rotating member multiplied by an integer.

6 Claims, 10 Drawing Sheets

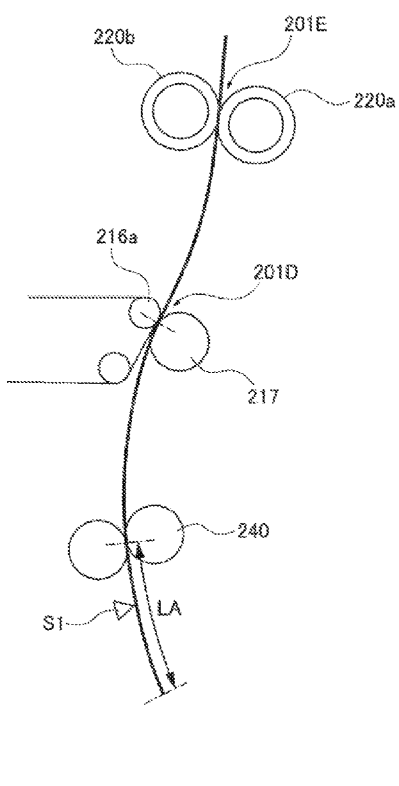

FIG 1

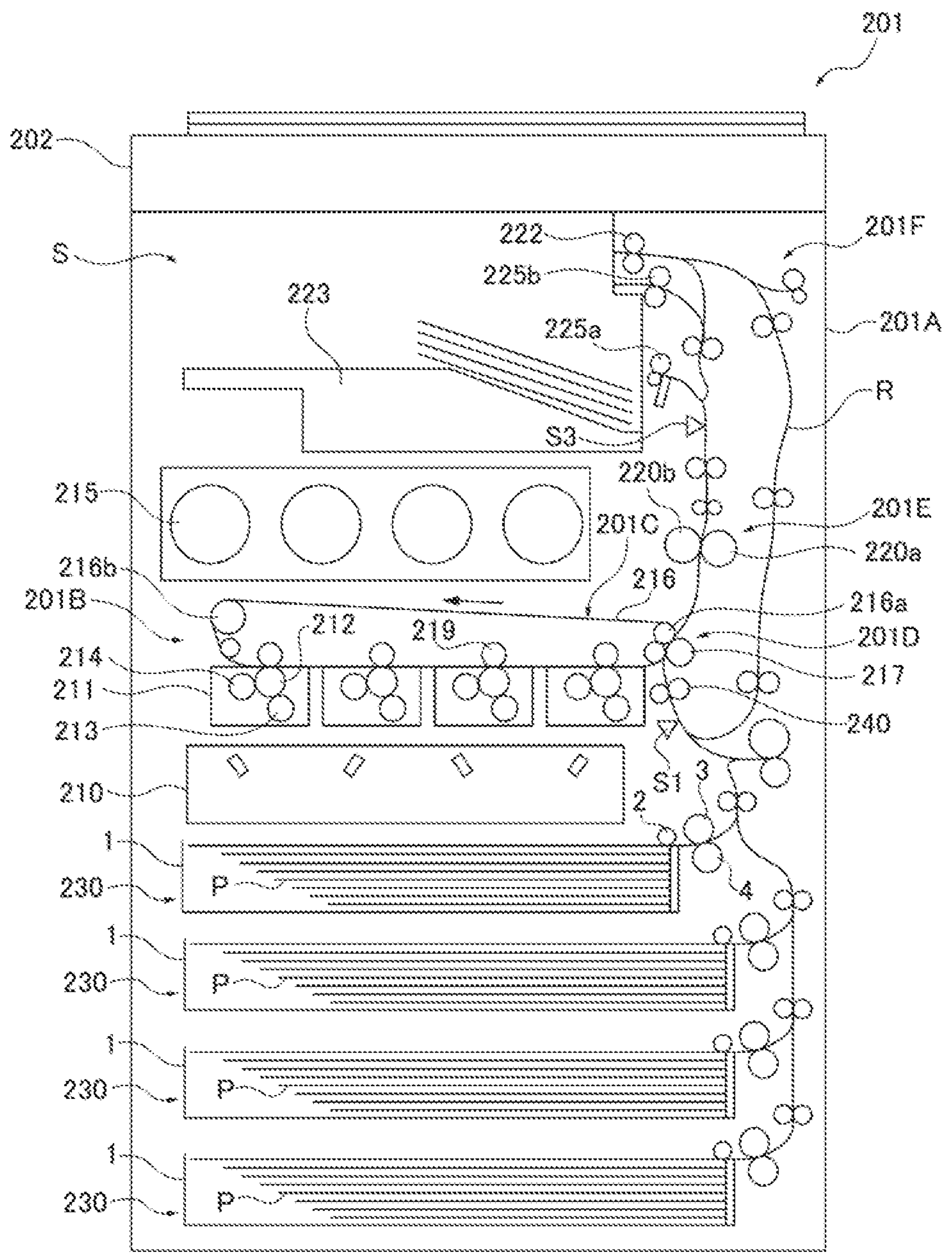
201
202
201F
222
225b
S
223
225a
201A
R
S3
220b
215
201E
201C
220a
216b
216
216a
201B
212
219
201D
214
217
211
240
213
S1
3
210
2
1
4
230
P
1
230
P
1
230
P
1
230
P

FIG 2

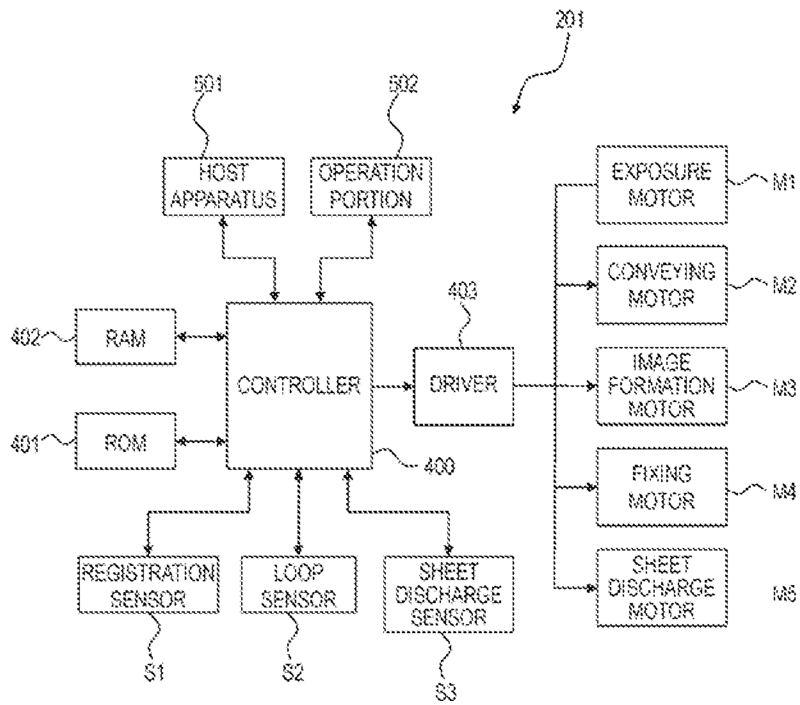
201
501
HOST APPARATUS
502
OPERATION PORTION
402
RAM
401
ROM
CONTROLLER
400
403
DRIVER
EXPOSURE MOTOR
M1
CONVEYING MOTOR
M2
IMAGE FORMATION MOTOR
M3
FIXING MOTOR
M4
SHEET DISCHARGE MOTOR
M5
REGISTRATION SENSOR
S1
LOOP SENSOR
S2
SHEET DISCHARGE SENSOR
S3

FIG 3A

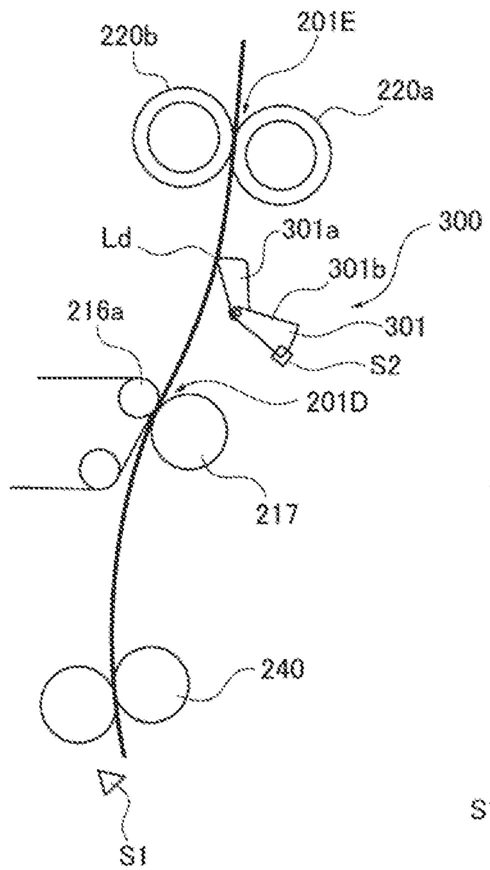
220b
201E
220a
Ld
301a
300
301b
216a
301
S2
201D
217
240
S1

FIG 3B

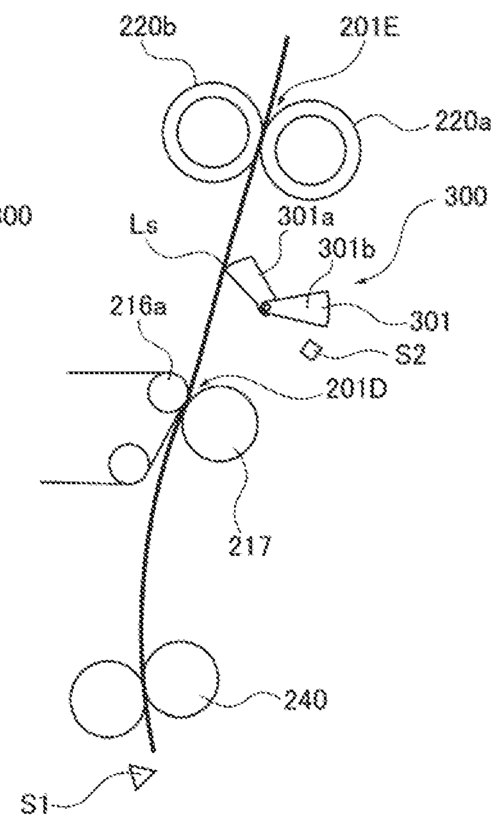
220b
201E
220a
300
Ls
301a
301b
216a
301
S2
201D
217
240
S1

FIG 4

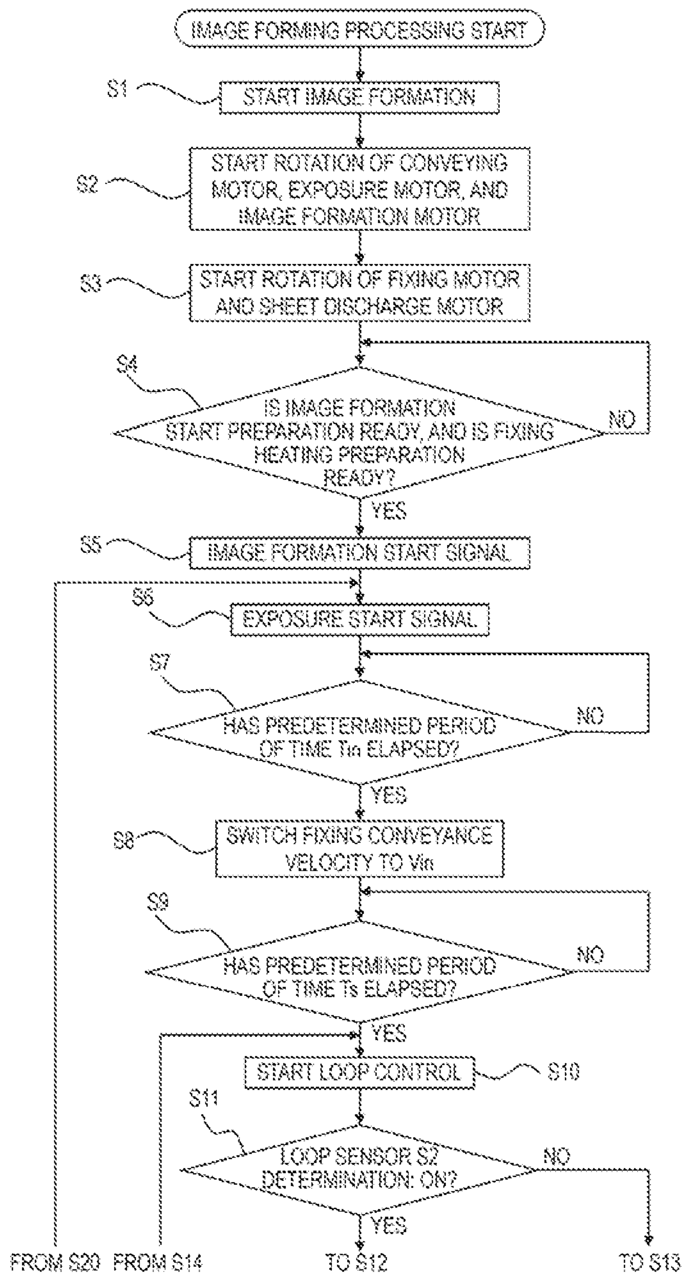
IMAGE FORMING PROCESSING START
S1
START IMAGE FORMATION
S2
START ROTATION OF CONVEYING MOTOR, EXPOSURE MOTOR, AND IMAGE FORMATION MOTOR
S3
START ROTATION OF FIXING MOTOR AND SHEET DISCHARGE MOTOR
S4
IS IMAGE FORMATION START PREPARATION READY, AND IS FIXING HEATING PREPARATION READY?
NO
YES
S5
IMAGE FORMATION START SIGNAL
S6
EXPOSURE START SIGNAL
S7
HAS PREDETERMINED PERIOD OF TIME Tn ELAPSED?
NO
YES
S8
SWITCH FIXING CONVEYANCE VELOCITY TO Vn
S9
HAS PREDETERMINED PERIOD OF TIME Ts ELAPSED?
NO
YES
START LOOP CONTROL
S10
S11
LOOP SENSOR S2 DETERMINATION: ON?
NO
YES
FROM S20
FROM S14
TO S12
TO S13

FIG 5

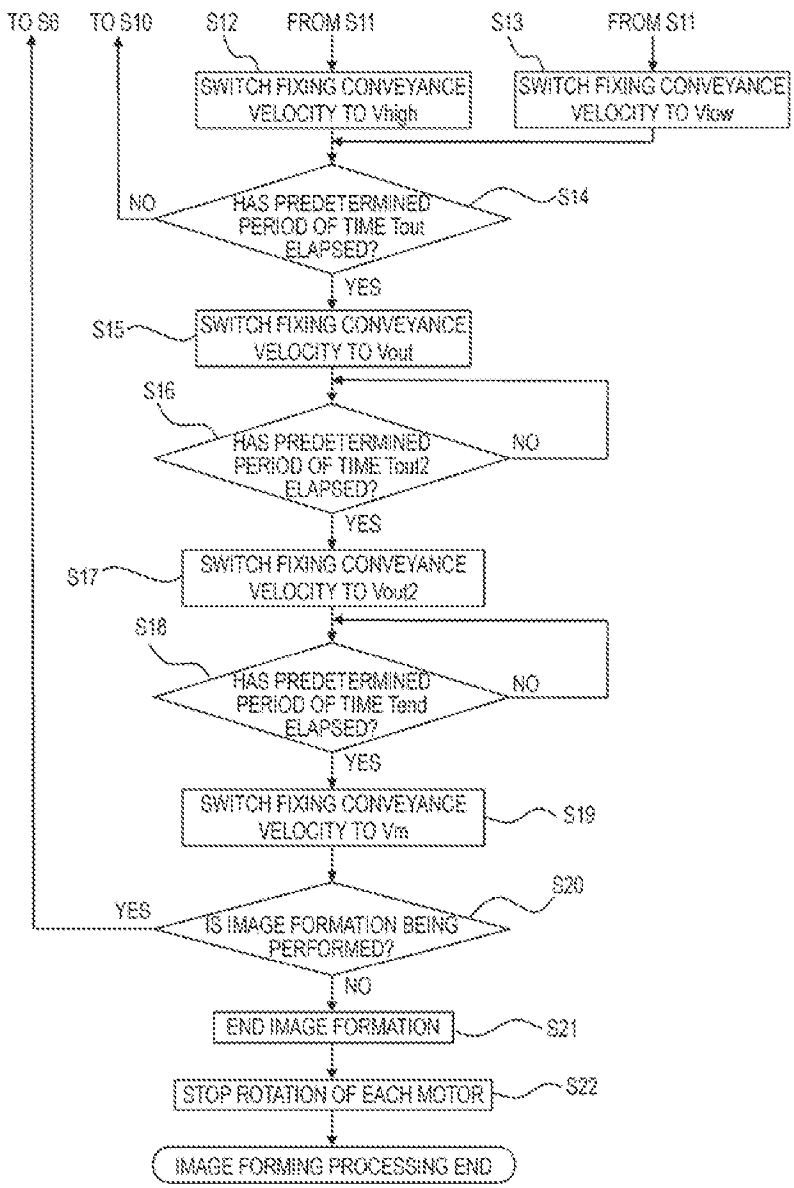
TO S6
TO S10
S12
FROM S11
S13
FROM S11
SWITCH FIXING CONVEYANCE VELOCITY TO Vhigh
SWITCH FIXING CONVEYANCE VELOCITY TO Vlow
NO
HAS PREDETERMINED PERIOD OF TIME Tout ELAPSED?
S14
YES
S15
SWITCH FIXING CONVEYANCE VELOCITY TO Vout
S16
HAS PREDETERMINED PERIOD OF TIME Tout2 ELAPSED?
NO
YES
S17
SWITCH FIXING CONVEYANCE VELOCITY TO Vout2
S18
HAS PREDETERMINED PERIOD OF TIME Tend ELAPSED?
NO
YES
SWITCH FIXING CONVEYANCE VELOCITY TO Vm
S19
YES
IS IMAGE FORMATION BEING PERFORMED?
S20
NO
END IMAGE FORMATION
S21
STOP ROTATION OF EACH MOTOR
S22
IMAGE FORMING PROCESSING END

FIG 6

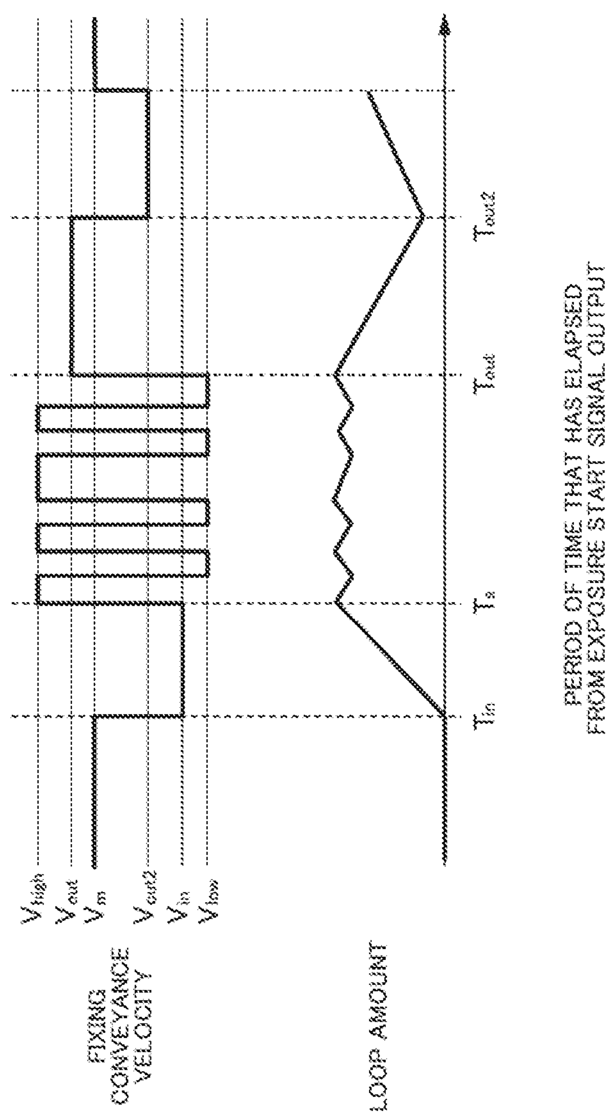
FIXING CONVEYANCE VELOCITY
V_{high}
V_{out}
V_m
V_{out2}
V_{in}
V_{low}
LOOP AMOUNT
T_{in}
T_s
T_{out}
T_{out2}
PERIOD OF TIME THAT HAS ELAPSED FROM EXPOSURE START SIGNAL OUTPUT

FIG 7

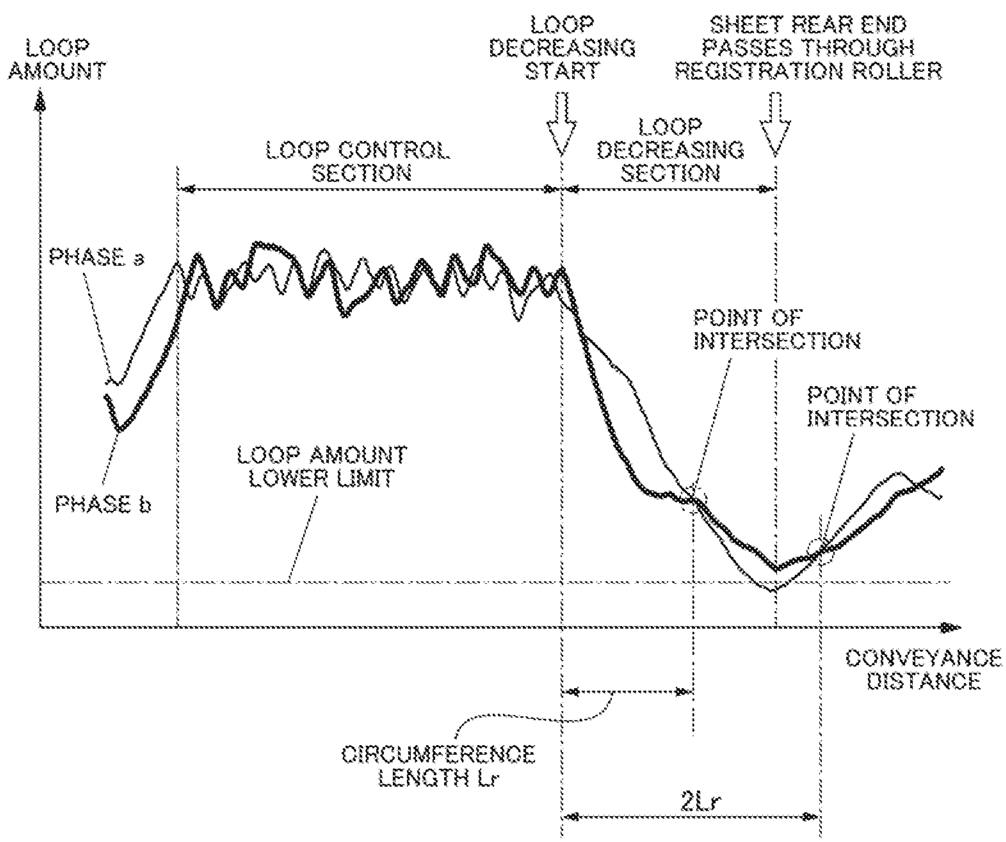
LOOP AMOUNT
LOOP DECREASING START
SHEET REAR END PASSES THROUGH REGISTRATION ROLLER
LOOP CONTROL SECTION
LOOP DECREASING SECTION
PHASE a
POINT OF INTERSECTION
POINT OF INTERSECTION
LOOP AMOUNT LOWER LIMIT
PHASE b
CONVEYANCE DISTANCE
CIRCUMFERENCE LENGTH Lr
2Lr

FIG 8

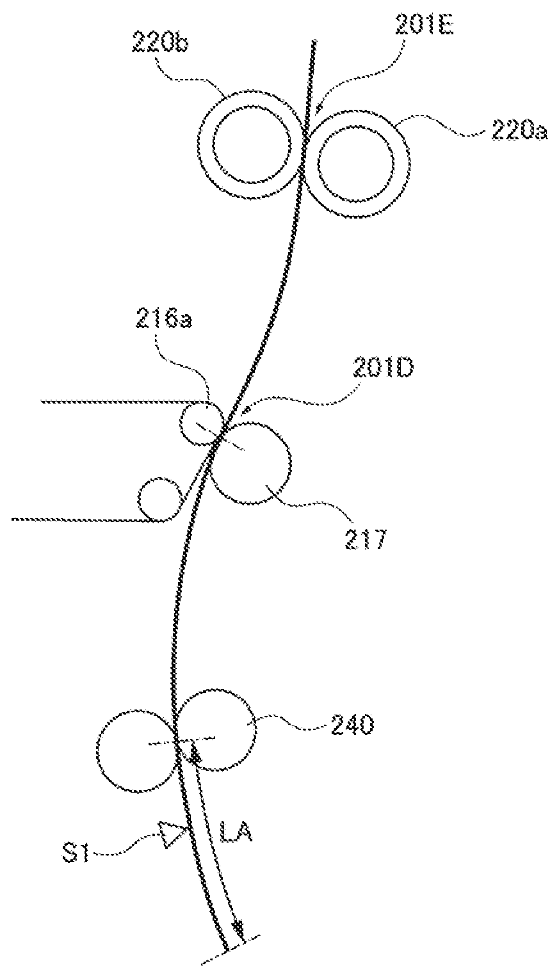

FIG 9

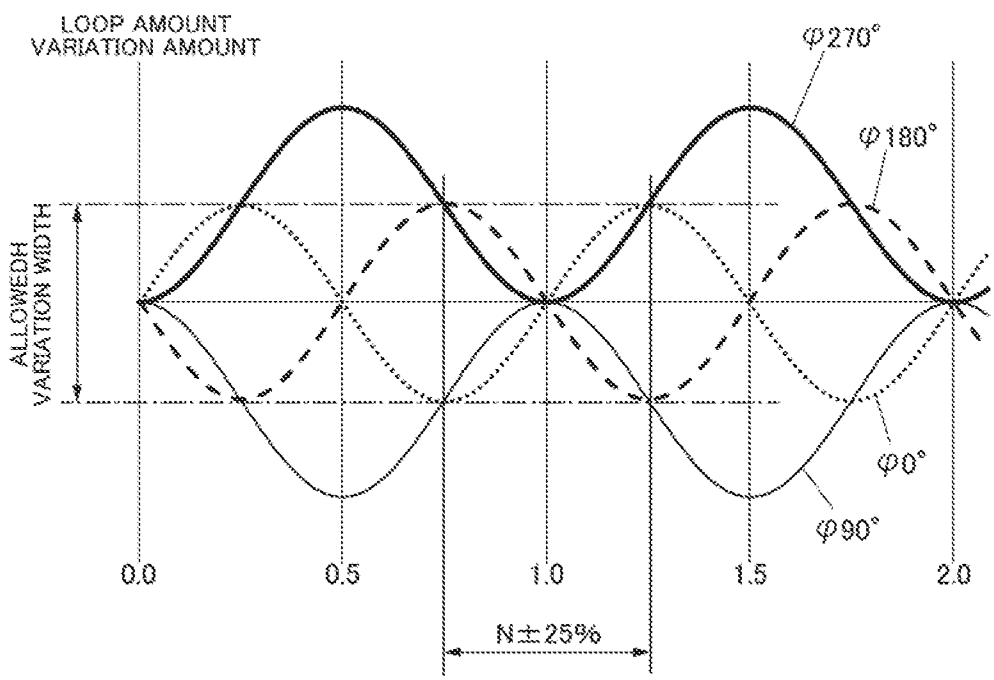
LOOP AMOUNT
VARIATION AMOUNT
φ270°
φ180°
ALLOWEDH
VARIATION WIDTH
φ0°
φ90°
0.0
0.5
1.0
1.5
2.0
N±25%

FIG 10

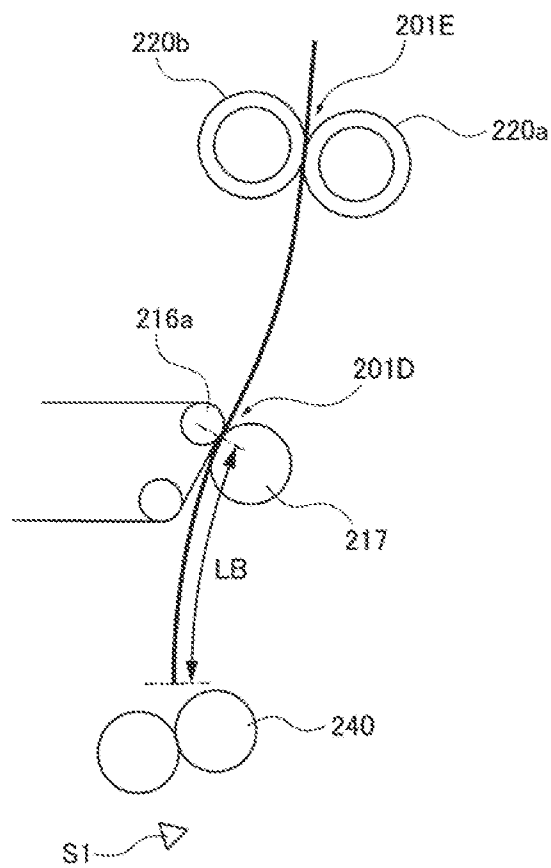

IMAGE FORMING APPARATUS CONTROLLING RECORDING MEDIUM LOOP

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image forming apparatus that uses an electrophotographic system, such as a copying machine, a printer, or a facsimile.

Description of the Related Art

Conventionally, in an image forming apparatus that uses an electrophotographic system, a sheet is conveyed by a conveying unit, and then toner images formed on image bearing members are transferred to the sheet by a transfer portion. Then, the sheet to which the toner images have been transferred is conveyed to a nip portion of a fixing portion to fix the toner images on the sheet. In such an image forming apparatus, a sheet may be conveyed in a state where the sheet is nipped between a fixing portion, a transfer portion, and a conveying unit.

Japanese Patent Application Laid-Open No. 10-97154 discloses an image forming apparatus that forms flexure called a loop in a sheet between a transfer portion and a fixing nip portion of a fixing apparatus, and performs loop control that senses an amount of the formed loop and maintains the amount of the loop at a predetermined amount.

Further, Japanese Patent Application Laid-Open No. 2003-241453 discloses an image forming apparatus that to prevent an image defect due to a bending reaction force generated in a sheet in which a loop is formed, switches a conveyance velocity of a fixing portion to a velocity that decreases a loop amount of the sheet immediately before a rear end of the sheet passes through a transfer portion. That is to say, the transfer portion and the fixing portion convey a sheet while forming a loop in the sheet. Then, the formed loop is decreased before a rear end of the sheet passes through the transfer portion. Consequently, an image defect in the sheet passing between the transfer portion and the fixing portion is prevented.

However, in recent years, various types of sheets have been needed to be conveyed. To convey a sheet short in a conveyance direction, a distance between a transfer portion and a conveying portion provided upstream from the transfer portion and conveying a sheet has become short. Further, since a sheet having high stiffness is conveyed, a value of a bending reaction force generated in the sheet in which a loop is formed has become large. In this case, when a rear end of the sheet passes through the conveying portion, the sheet receives an effect of a bending reaction force of a loop formed by the transfer portion and a fixing portion. As a result, there is a possibility that a sheet behavior is distorted, and an image defect is generated.

Further, a fixing roller has an outer diameter that varies according to rotational phases, due to a component tolerance, a temperature unevenness, or the like. Therefore, a conveyance velocity of a sheet may vary while the fixing roller rotates one time. That is to say, when a loop amount is decreased, the loop amount of a sheet regularly varies. As a result, a loop amount of a sheet between a fixing nip portion and a transfer portion becomes excessive or insufficient, according to rotational phases of the fixing roller, and there has been a possibility that an image defect is generated.

SUMMARY OF THE INVENTION

It is desirable to provide an image forming apparatus that restricts generation of an image defect even if a diameter of a rotating member of a fixing portion varies according to rotational phases.

An image forming apparatus according to an aspect of the present invention includes: a transfer unit that forms a transfer nip portion, and conveys a recording medium while transferring a toner image formed on an image bearing member; a conveying unit that is provided upstream of the transfer unit in a conveyance direction of the recording medium, forms a conveying nip portion, and conveys the recording medium to the transfer unit; a fixing unit that are included a heating rotating member, and a pressure-applying rotating member that forms a fixing nip portion together with the heating rotating member, and conveys the recording medium while heating the toner image transferred to the recording medium by the transfer unit, at the fixing nip portion, to melt and fix the toner image on the recording medium; and a control unit that controls a conveyance velocity of conveying the recording medium by the fixing unit, to form a loop in the recording medium between the transfer nip portion and the fixing nip portion, in which the control unit controls the conveyance velocity to decrease the loop when a rear end of the recording medium reaches a first position that is apart upstream, in the conveyance direction, from the conveying nip portion of the conveying unit, by a distance that corresponds to a circumference length of the pressure-applying rotating member multiplied by an integer.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of an image forming apparatus according to a first embodiment of the present invention;

FIG. **2** is a block diagram that illustrates a configuration of the image forming apparatus according to the first embodiment of the present invention;

FIGS. **3**A and **3**B are schematic views that enlarge part of the image forming apparatus according to the first embodiment of the present invention;

FIG. **4** is a flowchart that illustrates a former half of image forming processing according to the first embodiment of the present invention;

FIG. **5** is a flowchart that illustrates a latter half of the image forming processing according to the first embodiment of the present invention;

FIG. **6** is a drawing that illustrates a transition of a loop amount of a sheet in the image forming apparatus according to the first embodiment of the present invention;

FIG. **7** is a drawing that illustrates a transition of a loop amount of a sheet in a section that controls a loop amount of a sheet in the image forming apparatus according to the first embodiment of the present invention;

FIG. **8** is a schematic view that illustrates a state of a sheet at a time of a start of loop-amount decreasing processing in the image forming apparatus according to the first embodiment of the present invention;

FIG. **9** is a drawing that illustrates a variation in a loop amount at a time of changing a length of a section that decreases a loop amount in the image forming apparatus according to the first embodiment of the present invention; and

FIG. **10** is a schematic view that enlarges part of an image forming apparatus according to a second embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

Hereinafter, embodiments will be described in detail with reference to the drawings.

First Embodiment

Hereinafter, an image forming apparatus according to an embodiment of the present invention will be described in detail, appropriately with reference to the drawings.

<Configuration of Image Forming Apparatus>

A configuration of an image forming apparatus **201** according to a first embodiment of the present invention will be described in detail with reference to FIGS. **1** and **2**.

The image forming apparatus **201** forms an image that is full-color or monochrome and corresponds to printing image data output from a host apparatus **501**, on a sheet P as a recording medium, and outputs the sheet P on which the image has been formed. Here, a laser beam printer that uses an electrophotographic process and is of a tandem system and an intermediate transfer system is exemplified as the image forming apparatus **201**.

More specifically, the image forming apparatus **201** includes an apparatus main body **201**A, an image forming portion **201**B, a duplex reversing portion **201**F, an image reading apparatus **202**, and sheet feeding apparatuses **230**. The image forming apparatus **201** also includes a controller **400**, read-only memory (ROM) **401**, random-access memory (RAM) **402**, a driver **403**, an operation portion **502**, an exposure motor M**1**, a conveying motor M**2**, an image formation motor M**3**, a fixing motor M**4**, and a sheet discharge motor M**5**. Further, the image forming apparatus **201** includes a registration sensor S**1**, a loop sensor S**2**, and a sheet discharge sensor S**3**. A discharge space S for discharging sheets P is formed between the image reading apparatus **202** and the apparatus main body **201**A.

The apparatus main body **201**A contains the image forming portion **201**B and the like.

The image forming portion **201**B forms an image on a sheet P. Here, a four-drum full-color system is exemplified as the image forming portion **201**B. Note that details of a configuration of the image forming portion **201**B will be described below.

The duplex reversing portion **201**F includes a reconveyance passage R that conveys a sheet P on one side of which an image has been formed, to the image forming portion **201**B again.

The image reading apparatus **202** is substantially horizontally installed over the apparatus main body **201**A.

The sheet feeding apparatuses **230** feed a sheet P to a registration roller **240**. The sheet feeding apparatus **230** includes a sheet cassette **1**, a pickup roller **2**, a feed roller **3**, and a retard roller **4**.

The sheet cassette **1** contains sheets P.

The pickup roller **2** feeds sheets P contained in the sheet cassette **1**, to the feed roller **3** and the retard roller **4**.

The feed roller **3** and the retard roller **4** separate and feed sheets P fed from the pickup roller **2**, to the registration roller **240**.

The controller **400** as a control unit is a central processing unit (CPU) or the like with which the host apparatus **501** is connected. The controller **400** gives and receives information to and from the host apparatus **501** or the operation portion **502**. The controller **400** executes programs stored in the ROM **401** to collectively control each operation including an image forming operation of the image forming apparatus **201**, perform signal processing, sequence control, and the like to various process equipment, and execute image forming processing described below. Here, the host apparatus **501** is a personal computer, an image scanner, a facsimile, or the like.

The ROM **401** preliminarily stores programs executed by the controller **400**. The ROM **401** stores sizes and types of sheets P, image formation color modes, image formation modes of single-sided printing or duplex printing, a control condition table used to selectively guide image formation conditions, and control conditions, such as rotational speeds of each of the motors, that correspond to the image formation modes.

The RAM **402** stores variables of programs executed by the controller **400**, variables used for various control, conditions to be changed, among the control conditions stored in the ROM **401**, arithmetic values, and set values that can be rewritten according to situations.

Due to control by the controller **400**, the driver **403** controls an electric-current value (pulse width modulation (PWM) signal) flowing to the exposure motor M**1**, the conveying motor M**2**, the image formation motor M**3**, the fixing motor M**4**, or the sheet discharge motor M**5** so that the rotational speed becomes a target speed.

The operation portion **502** outputs information input by operation of a user, to the controller **400**.

The exposure motor M**1** is a motor mainly forming latent images, and performs rotation driving by control by the driver **403**.

The conveying motor M**2** is a motor mainly performing conveyance of a sheet P, and performs rotation driving by control by the driver **403**. The conveying motor M**2** uses a gear train, an electromagnetic clutch, and the like of driving transmission that are not illustrated, to rotate each roller for feeding or conveying a sheet P in the image forming portion **201**B, at determined timings.

The image formation motor M**3** is a motor mainly forming images, and undertaking image formation in the image forming portion **201**B. The image formation motor M**3** performs rotation driving by control by the driver **403** to form and convey toner images at an extremely accurate constant velocity.

The fixing motor M**4** performs rotation driving by control by the driver **403** to mainly make a fixing nip portion of a fixing portion **201**E described below convey a sheet P.

The sheet discharge motor M**5** performs rotation driving by control by the driver **403** to mainly discharge a sheet P into the discharge space S from the image forming portion **201**B, or convey a sheet P to the reconveyance passage R, like a switchback.

The registration sensor S**1** as a sensing unit is provided upstream, in a conveyance direction, from the registration roller **240**, and detects a front end, in a conveyance direction of a sheet P fed from the sheet feeding apparatus **230** (hereinafter, simply referred to as the “conveyance direction”), of the sheet P, and outputs the detection result to the controller **400**.

The loop sensor S**2** is a photointerrupter that detects the presence or absence of light interruption according to a loop amount of a sheet P conveyed in the image forming portion

201B, and outputs a signal corresponding to the presence or absence of the light interruption, to the controller **400**.

The sheet discharge sensor S**3** detects a discharge of a sheet P, and outputs the detection result to the controller **400**.

<Configuration of Image Forming Portion>

A configuration of the image forming portion **201**B according to the first embodiment of the present invention will be described in detail with reference to FIGS. **1** to **3**B.

The image forming portion **201**B includes a laser scanner **210**, process cartridges **211**, a toner cartridge **215**, a transfer belt **216**, a driving roller **216***a*, and a tension roller **216***b*. The image forming portion **201**B also includes a secondary transfer roller **217**, primary transfer rollers **219**, a fixing roller **220***a*, and a heating roller **220***b*. Further, the image forming portion **201**B includes a pair of reversing rollers **222**, a stacking portion **223**, a pair of first discharge rollers **225***a*, a pair of second discharge rollers **225***b*, the registration roller **240**, and a loop detection portion **300**.

Here, the process cartridges **211** and the primary transfer rollers **219** constitute a primary transfer portion **201**C. Here, the driving roller **216***a* and the secondary transfer roller **217** constitute a secondary transfer portion **201**D arranged above the process cartridges **211**. The fixing roller **220***a* and the heating roller **220***b* constitute the fixing portion **201**E as a fixing unit arranged above the secondary transfer roller **217**.

Between the secondary transfer portion **201**D and the fixing portion **201**E, a mechanism performing conveyance of a sheet P, such as rollers and a belt, is not provided. Therefore, the secondary transfer portion **201**D and the fixing portion **201**E are arranged in such a manner that a distance between the secondary transfer portion **201**D and the fixing portion **201**E is shorter than a length, in the conveyance direction, of a sheet P having the shortest length, in the conveyance direction, of usable sheets P.

The laser scanner **210** includes semiconductor lasers provided and corresponding to each of colors of yellow (Y), magenta (M), cyan (C), and black (B) any of which is not illustrated, and a corner surface body polygon mirror.

The semiconductor lasers are each switched on and emit laser light, based on image data transmitted from the image reading apparatus **202** and corresponding to each of the colors of yellow, magenta, cyan, and black. The corner surface body polygon mirror is driven by the exposure motor M**1** performing rotation driving to perform deflection scanning with laser light emitted from each of the semiconductor lasers to form an electrostatic latent image on the photosensitive drum **212** of each of the process cartridges **211**. Note that instead of the laser scanner **210**, the image forming portion **201**B may use an exposure apparatus that performs light-emitting diode (LED) switching control or the like.

The four process cartridges **211** are provided to form toner images of four colors of yellow, magenta, cyan, and black. Each of the process cartridges **211** includes the photosensitive drum **212**, a charging device **213**, and a development device **214**.

The photosensitive drums **212** are image bearing members that rotate by the image formation motor M**3** performing rotation driving. Surfaces of the photosensitive drums **212** are uniformly charged with a predetermined polarity and a predetermined electric potential by the charging devices **213**. The uniformly charged surfaces of the photosensitive drums **212** are sequentially exposed to laser light emitted from the laser scanner **210** to form electrostatic latent images on the photosensitive drums **212**, and the electrostatic latent images are developed by the development devices **214** to form toner images as developer images.

The charging devices **213** uniformly charge surfaces of the photosensitive drums **212** with a predetermined polarity and a predetermined electric potential.

The development devices **214** include developer conveying screws not illustrated. The developer conveying screws are driven by the image formation motor M**3** performing rotation driving, to provide toners of four colors of yellow, magenta, cyan, and black for the photosensitive drums **212**. The development devices **214** develop electrostatic latent images formed on surfaces of the photosensitive drums **212** with toners of four colors of yellow, magenta, cyan, and black, or a toner of a single color, to form toner images on the surfaces of the photosensitive drums **212**.

The toner cartridge **215** provides toners of four colors of yellow, magenta, cyan, and black for each of the development devices **214** of each of the process cartridges **211**, respectively.

The transfer belt **216** is wound around the driving roller **216***a* and the tension roller **216***b*.

The driving roller **216***a* rotates by the image formation motor M**3** performing rotation driving, and drives and rotates the transfer belt **216** in a direction of an arrow in FIG. **1**.

The tension roller **216***b* drives and rotates the transfer belt **216** in a direction of the arrow in FIG. **1**.

The secondary transfer roller **217** as a transfer unit is provided at a position opposite the driving roller **216***a*, and rotates by the image formation motor M**3** performing rotation driving, to convey a sheet P conveyed from the registration roller **240** to the fixing portion **201**E. The secondary transfer roller **217**, together with the driving roller **216***a*, forms a transfer nip portion and nips the transfer belt **216** and a sheet P, and transfers a toner image transferred onto the transfer belt **216**, to the sheet P.

The primary transfer rollers **219** are provided inside the transfer belt **216**, and abut the transfer belt **216** at positions opposite the photosensitive drums **212**. The primary transfer rollers **219** rotate by the image formation motor M**3** performing rotation driving. The primary transfer rollers **219**, together with the photosensitive drums **212**, nip the transfer belt **216**, and transfer toner images formed on the photosensitive drums **212**, to the transfer belt **216**.

The fixing roller **220***a* as a pressure-applying rotating member rotates by the fixing motor M**4** performing rotation driving, and forms a fixing nip portion where a sheet P conveyed from the secondary transfer portion **201**D is nipped and conveyed between the fixing roller **220***a* and the heating roller **220***b*.

The heating roller **220***b* as a heating rotating member heats toner images transferred to a sheet P by the secondary transfer portion **201**D, at the fixing nip portion, to melt and fix the toner images on the sheet P.

The pair of reversing rollers **222** are rollers that can rotate regularly and oppositely. The pair of reversing rollers **222** rotates by the sheet discharge motor M**5** performing rotation driving.

The stacking portion **223** protrudes in a bottom surface of the discharge space S, and sequentially stacks sheets P discharged by the pair of first discharge rollers **225***a* or the pair of second discharge rollers **225***b*.

The pair of first discharge rollers **225***a* rotates by the sheet discharge motor M**5** performing rotation driving, to discharge a sheet P conveyed from the fixing portion **201**E, into the stacking portion **223**.

The pair of second discharge rollers **225***b* rotates by the sheet discharge motor M**5** performing rotation driving, to discharge a sheet P conveyed from the fixing portion **201**E, into the stacking portion **223**.

The registration roller **240** as a conveying unit is driven and rotated by the conveying motor M**2**. The registration roller **240** forms a conveying nip portion, corrects skew feeding of sheets P conveyed, one sheet by one sheet, from the sheet feeding apparatus **230**, and conveys the sheet P skew feeding of which has been corrected, to the secondary transfer portion **201**D.

The loop detection portion **300** as a loop detection unit is provided in a conveyance path between the secondary transfer portion **201**D and the fixing portion **201**E, as illustrated in FIGS. **3**A and **3**B. The loop detection portion **300** detects a first loop state Ls illustrated in FIG. **3**B that is a state where a loop of a sheet P is shallow, and a second loop state Ld illustrated in FIG. **3**A that is a state where a loop of a sheet P is deep. More specifically, the loop detection portion **300** includes a loop sensor flag **301**, a loop sensor flag spring not illustrated, and the loop sensor S**2**.

The loop sensor flag **301** can swing, and is energized by the loop sensor flag spring to maintain a state where the loop sensor flag **301** protrudes into the conveyance path. The loop sensor flag **301** includes a sheet abutting portion **301***a* and a sensor portion **301***b*. The sheet abutting portion **301***a* protrudes into the conveyance path to be in contact with a sheet P being conveyed between the secondary transfer portion **201**D and the fixing portion **201**E. The sheet abutting portion **301***a* swings according to a loop amount that the sheet P forms along the conveyance path. The sensor portion **301***b* swings integrally with the sheet abutting portion **301***a*, and interrupts or does not interrupt light to a sensing portion of the loop sensor S**2**.

The loop sensor S**2** is provided between the secondary transfer portion **201**D and the fixing portion **201**E. Here, a photointerrupter is exemplified as the loop sensor S**2**. The loop sensor S**2** outputs an ON signal to the controller **400** if light is interrupted by the sensor portion **301***b*, as illustrated in FIG. **3**A, and outputs an OFF signal to the controller **400** if light is not interrupted by the sensor portion **301***b*, as illustrated in FIG. **3**B.

Note that the loop detection portion **300** is not limited to a case where a loop is detected by the loop sensor S**2** as a photointerrupter and the loop sensor flag **301**, but may detect a loop by means of an optical sensor that directly detects a conveyance state of a sheet P.

<Operations of Image Forming Apparatus>

Operations of the image forming apparatus **201** according to the first embodiment of the present invention will be described in detail.

First, the image reading apparatus **202** reads image information of an original, and performs image processing of the read image information, and then converts the processed image information into an electrical signal, and transmits the electrical signal to the laser scanner **210** of the image forming portion **201**B.

Next, the image forming portion **201**B uniformly charges surfaces of the photosensitive drums **212** with a predetermined polarity and a predetermined electric potential by means of the charging devices **213**.

Next, based on the electrical signal transmitted from the image reading apparatus **202**, the image forming portion **201**B irradiate the surfaces of the photosensitive drums **212** with laser light by means of the laser scanner **210** to sequentially expose the surfaces of the photosensitive drums **212**. Consequently, electrostatic latent images that are of yellow, magenta, cyan, and black, and correspond to the image information read by the image reading apparatus **202** are sequentially formed on the photosensitive drum **212** of each of the process cartridges **211**.

Next, the image forming portion **201**B develops the electrostatic latent images on the photosensitive drums **212**, with a toner of each of the colors, by means of the development devices **214**, to form toner images and make the electrostatic latent images visible.

Next, the image forming portion **201**B sequentially superimposes and transfers the toner images of each of the colors on each of the photosensitive drums **212**, on and to the transfer belt **216**, by means of first transfer biases applied to the primary transfer rollers **219**. Consequently, toner images are formed on the transfer belt **216**.

In parallel to the operations described above, sheets P are conveyed, one sheet by one sheet, to the registration roller **240**, by the sheet feeding apparatus **230**. Skew feeding of the sheets P is corrected by the registration roller **240**. The registration sensor S**1** detects the sheets P reaching a predetermined position.

The sheet P skew feeding of which has been corrected is conveyed to the secondary transfer portion **201**D by the registration roller **240**. At the secondary transfer portion **201**D, the toner images formed on the transfer belt **216** are collectively transferred to the sheet P by means of a secondary transfer bias applied to the secondary transfer roller **217**.

Next, the sheet P to which the toner images have been transferred is conveyed to the fixing portion **201**E. Because the sheet P conveyed to the fixing portion **201**E receives heat and pressure, the toners of each of the colors melt, the colors mix, and the toners are fixed on the sheet P, as a color image, or a black toner melts and is fixed on the sheet P, as a black and white image.

Because a conveyance velocity difference is provided for the secondary transfer portion **201**D and the fixing portion **201**E, flexure called a loop between the secondary transfer portion **201**D and the fixing portion **201**E is formed in a sheet P that is being conveyed between the secondary transfer portion **201**D and the fixing portion **201**E. Note that processing that forms such a loop will be described in detail in image forming processing described below.

Next, the sheet P on which the image has been fixed is discharged into the discharge space S by the pair of first discharge rollers **225***a* and the pair of second discharge rollers **225***b* provided downstream, in the conveyance direction, from the fixing portion **201**E, and is stacked on the stacking portion **223** protruded in a bottom surface of the discharge space S.

Note that when images are formed on both sides of a sheet P, the sheet P on a front side of which an image has been fixed is conveyed to the reconveyance passage R by the pair of reversing rollers **222**, and conveyed to the image forming portion **201**B again, and an image is formed on the back side by means of operations similar to the operations described above, and the sheet P is discharged.

<Image Forming Processing>

Image forming processing according to the first embodiment of the present invention will be described in detail with reference to FIGS. **3**A to **9**.

The image forming processing illustrated in FIGS. **4** and **5** is started at a timing when the controller **400** acquires printing data from the host apparatus **501**, and information regarding image formation, such as a size of a sheet P, is input into the controller **400** from the operation portion **502**.

First, the controller **400** converts the acquired printing data into image data, and outputs an image formation start instruction signal to the driver **403** to start image formation (S**1**).

Next, the controller **400** starts rotation of the exposure motor M**1**, the conveying motor M**2**, and the image formation motor M**3** through the driver **403**, at predetermined rotational speeds stored in the ROM **401** (S**2**).

Next, the controller **400** heats the heating roller **220***b* by means of a heater not illustrated of the fixing portion **201**E. Then, when a surface of the heating roller **220***b* reaches a predetermined temperature among the control conditions stored in the ROM **401**, the controller **400** issues an instruction on fixing heating preparation to the driver **403**, and starts rotation of the fixing motor M**4** through the driver **403** (S**3**). At this time, the controller **400** makes the fixing motor M**4** rotate at a rotational speed Rm stored in the ROM **401** to make a fixing conveyance velocity become Vm.

Further, the controller **400** starts rotation of the sheet discharge motor M**5** through the driver **403** synchronously with the start of rotation of the fixing motor M**4** (S**3**). The controller **400** makes the sheet discharge motor M**5** rotate at a rotational speed Rex stored in the ROM **401** so that a sheet discharge conveyance velocity Vex becomes slower than a velocity Vs of the transfer belt **216** (Vs>Vex).

Next, the controller **400** determines whether or not the fixing heating preparation of the fixing portion **201**E is ready, and image formation start preparation of the exposure motor M**1**, the conveying motor M**2**, the image formation motor M**3**, the fixing motor M**4**, and the sheet discharge motor M**5** is ready (S**4**).

If the fixing heating preparation is not ready, or the image formation start preparation is not ready (S**4**: No), the controller **400** repeats the processing of step S**4**.

On the other hand, if the fixing heating preparation is ready, and the image formation start preparation is ready (S**4**: Yes), the controller **400** outputs an image formation start signal to the driver **403** (S**5**). Then, the controller **400** makes the conveying motor M**2** perform rotation driving through the driver **403** so that sheets P are fed from the sheet cassette **1**, and conveyed, one sheet by one sheet, to the registration roller **240**, or a sheet P is conveyed from the reconveyance passage R to the registration roller **240**. After the sheet P is carried into the registration roller **240**, the controller **400** temporarily stops the conveying motor M**2** through the driver **403** to make the sheet P stand by at the registration roller **240**.

Further, the controller **400** makes the image formation motor M**3** perform rotation driving through the driver **403** to drive the transfer belt **216** at the constant velocity Vs. Further, the controller **400** makes the exposure motor M**1** perform rotation driving through the driver **403** so that a writing velocity of an electrostatic latent image on the photosensitive drum **212** in each of the process cartridges **211** after a start of exposure substantially corresponds to the velocity Vs of the transfer belt **216**. Note that the writing velocity of an electrostatic latent image on the photosensitive drum **212** is calculated by the controller **400**, based on a result of reading a velocity stabilization control patch, not illustrated, on the transfer belt **216** before image formation, and is set according to conditions recorded in the ROM **401**.

Next, the controller **400** outputs an exposure start signal to the driver **403** (S**6**). Consequently, the exposure motor M**1** performs rotation driving by control by the driver **403** to start to form an electrostatic latent image on the photosensitive drum **212** of each of the process cartridges **211**. Then, after toner images formed on the photosensitive drums **212** start to be transferred to the transfer belt **216**, the controller **400** outputs a sheet refeeding start instruction signal to the driver **403** so that the registration roller **240** is driven and rotated through the driver **403** to start to convey the sheet P.

At this time, the controller **400** output the sheet refeeding start instruction signal at a timing that allows the toner images formed on the transfer belt **216** to be transferred to the sheet P detected by the registration sensor S**1**, at the secondary transfer portion **201**D. Consequently, the sheet P conveyed from the registration roller **240** reaches the secondary transfer portion **201**D, and is conveyed to the fixing portion **201**E while secondary transfer is performed to the sheet P.

Next, the controller **400** determines whether or not a predetermined period of time Tin has elapsed from a time of the output of the exposure start signal (S**7**). Here, a time of a lapse of the predetermined period of time Tin from the time of the output of the exposure start signal is a point after a front end, in the conveyance direction, of the sheet P (hereinafter, simply described as the "front end of the sheet P") passing through the secondary transfer portion **201**D, and before the front end of the sheet P reaching the fixing nip portion of the fixing portion **201**E.

If the predetermined period of time Tin has not elapsed (S**7**: No), the controller **400** repeats the processing of step S**7**.

On the other hand, if the predetermined period of time Tin has elapsed (S**7**: Yes), the controller **400** changes a rotational speed of the fixing motor M**4** into a rotational speed Rin stored in the ROM **401** to switch the fixing conveyance velocity from the velocity Vm to a velocity Vin (S**8**).

Here, the velocity Vin is set to a velocity slower than the velocity Vm, as illustrated in FIG. **6**, and slower than the velocity Vs of the transfer belt **216** so that a loop is formed in the sheet P between the secondary transfer portion **201**D and the fixing portion **201**E. Due to the forming a loop in the sheet P, the sheet P is not pulled by the fixing portion **201**E, and a secondary transfer image is not distorted.

Further, if a color image is formed, the predetermined period of time Tin is calculated as follows:

(1) It is supposed that a distance from an exposure position on the photosensitive drum **212** of the process cartridge **211** performing yellow image formation (at the left end in FIG. **1**), to a transfer nip position (primary transfer position) between the photosensitive drum **212** and the primary transfer roller **219** is A.

(2) It is supposed that a distance from the transfer nip position of (1) described above to a transfer nip position that is on the photosensitive drum **212** of the process cartridge **211** performing black image formation (at the right end in FIG. **1**), and is between the photosensitive drum **212** and the primary transfer roller **219** is B.

(3) It is supposed that a distance from the transfer nip position that is on the photosensitive drum **212** of the process cartridge **211** performing black image formation, and is between the photosensitive drum **212** and the primary transfer roller **219**, to a transfer position of the secondary transfer portion **201**D is C.

(4) It is supposed that a distance from the transfer position of the secondary transfer portion **201**D to an optional position before the fixing nip portion of the fixing portion **201**E is D.

(5) The predetermined period of time Tin is calculated by dividing the four distances A, B, C, and D added together, by the velocity Vs of the transfer belt **216** that has been set (Tin=(A+B+C+D)/Vs).

The distances A, B, and C described above are distances depending on a configuration of the image forming apparatus **201**, and is preliminarily stored in the ROM **401**. The distance D and the velocity Vs of the transfer belt **216** are stored in the RAM **402** in such a manner that the distance D and the velocity Vs of the transfer belt **216** can be changed as necessary. Therefore, the controller **400** can calculate the predetermined period of time Tin by using the distances A, B, and C stored in the ROM **401**, and the distance D and the velocity Vs of the transfer belt **216** stored in the RAM **402**.

Next, the controller **400** determines whether or not a predetermined period of time Ts has elapsed from the time of the output of the exposure start signal (S**9**). Here, a time of a lapse of the predetermined period of time Ts from the time of the output of the exposure start signal is a point after the front end of the sheet P passing through the fixing portion **201**E, and before a rear end, in the conveyance direction, of the sheet P (hereinafter, simply described as the "rear end of the sheet P") passing through the registration roller **240**.

In a case of before a lapse of the predetermined period of time Ts (S**9**: No), the controller **400** repeats the processing of step S**9**.

On the other hand, if the predetermined period of time Ts has elapsed (S**9**: Yes), the controller **400** starts loop control that selectively switches the fixing conveyance velocity to make a loop amount of the sheet P between the secondary transfer portion **201**D and the fixing portion **201**E become substantially constant (S**10**). In the loop control, the controller **400** controls the loop amount in such a manner that the loop amount is within a predetermined range by selectively switching the fixing conveyance velocity, based on a detection result with the loop sensor S**2** that follows and is obtained by an operation of the loop sensor flag **301** abutting the sheet P.

Note that a timing of the loop control start may be set to a time before the front end of the sheet P reaching the fixing portion **201**E.

Next, based on an ON signal or OFF signal input from the loop sensor S**2**, the controller **400** determines whether or not determination is ON determination (S**11**).

In a case of ON determination due to input of an ON signal from the loop sensor S**2** (S**11**: Yes), the controller **400** determines that the sheet P is in the second loop state Ld illustrated in FIG. **3**A. Then, to eliminate the loop, the controller **400** makes the fixing motor M**4** rotate at a rotational speed Rhigh stored in the ROM **401** so that the fixing conveyance velocity is switched to a velocity Vhigh (second velocity) faster than the velocity Vs of the transfer belt **216** (Vs<Vhigh) (S**12**).

On the other hand, in a case of OFF determination due to input of an OFF signal from the loop sensor S**2** (S**11**: No), the controller **400** determines that the sheet P is in the first loop state Ls illustrated in FIG. **3**B where the loop sensor flag **301** returns to a standing-by position, due to a decrease in a loop of the sheet P, or the like. Then, to form a loop, the controller **400** makes the fixing motor M**4** rotate at a rotational speed Rlow stored in the ROM **401** so that the fixing conveyance velocity is switched to a velocity Vlow (first velocity) slower than the velocity Vs of the transfer belt **216** (Vs>Vlow) (S**13**).

Next, the controller **400** determines whether or not a predetermined period of time Tout has elapsed from the time of the output of the exposure start signal (S**14**). Here, a time of a lapse of the predetermined period of time Tout from the time of the output of the exposure start signal is a point before the rear end of the sheet P passing through the registration roller **240**.

In a case of before a lapse of the predetermined period of time Tout (S**14**: No), the controller **400** returns to the processing of step S**10**.

On the other hand, if the predetermined period of time Tout has elapsed (S**14**: Yes), the controller **400** changes a rotational speed of the fixing motor M**4** into a rotational speed Rout stored in the ROM **401**. Consequently, the controller **400** switches the fixing conveyance velocity from the velocity Vhigh or velocity Vlow to a velocity Vout as a third velocity (S**15**).

The velocity Vout is a velocity slower than the velocity Vhigh and a velocity slightly faster than the velocity Vs of the transfer belt **216** (Vs<Vout<Vhigh), and is a velocity that can decrease a loop amount of a sheet P between the secondary transfer portion **201**D and the fixing portion **201**E. The reason why the velocity Vout is made faster than the velocity Vs of the transfer belt **216** is that when a rear end of a sheet P passes through the registration roller **240**, a loop amount of the sheet P between the secondary transfer portion **201**D and the fixing portion **201**E is made smaller than a predetermined amount. Consequently, a bending reaction force of the sheet P is decreased, and a secondary transfer image is not distorted.

Here, a method of determining a length of a section that decreases a loop amount of a sheet P between the secondary transfer portion **201**D and the fixing portion **201**E (hereinafter, described as the "loop decreasing section") will be described.

In the loop decreasing section, it is difficult to detect a loop amount with a simple configuration. Therefore, loop control is not performed, and the fixing roller **220***a* is driven at a constant rotational speed preliminarily stored in the ROM **401**. However, because the fixing roller **220***a* has a radius that varies in the circumference direction, a conveyance velocity varies while the fixing roller **220***a* rotates one time. Consequently, a loop amount of a sheet P regularly varies.

In FIG. **7**, a phase a and a phase b are rotational phases of the fixing roller **220***a* that become the fixing nip portion at a time of a start of a loop decreasing section. The phase a is a rotational phase that generates lines in an image at a timing when a rear end of a sheet P passes through the registration roller **240**. The phase b is a rotational phase that does not generate lines in an image at a timing when a rear end of a sheet P passes through the registration roller **240**.

As illustrated in FIG. **7**, since in a loop control section where loop control is performed, a loop amount is controlled to restrict variations due to the conveyance, the loop amount is a substantially constant value, irrespective of a rotational phase of the fixing roller **220***a* that becomes the fixing nip portion at a time of a start of the loop control section. On the other hand, in a loop decreasing section, the conveyance velocity varies according to a rotational phase of the fixing roller **220***a* that becomes the fixing nip portion at a time of a start of the loop decreasing section. Therefore, a loop amount also varies. In a case of FIG. **7**, a loop amount of a sheet P of the phase b is larger than a loop amount of a sheet P of the phase a, at a timing when rear ends of the sheets P pass through the registration roller **240**. The difference in the loop amounts causes the presence or absence of generation of the image defect.

On the other hand, as illustrated in FIG. **7**, a loop amount of the phase a and a loop amount of the phase b correspond at a distance Lr where the fixing roller **220***a* rotates one time from the time of the start of the loop decreasing section, and at a distance 2Lr where the fixing roller **220***a* rotates two times from the time of the start of the loop decreasing section. The reason is that a circumference length of the fixing roller **220***a* is constant, irrespective of rotational phases. Therefore, a distance that is the circumference length of the fixing roller **220***a* multiplied by an integer, and where a loop amount of the phase a and a loop amount of the phase b correspond is made to be a loop decreasing section. Consequently, variations in a loop amount due to rotational phases of the fixing roller **220***a* do not occur.

Consequently, in the present embodiment, the fixing conveyance velocity is controlled so that a length of a loop decreasing section becomes the circumference length of the fixing roller **220***a* multiplied by an integer. Consequently, a loop amount at a timing when a rear end of a sheet P passes through the registration roller **240** and an image defect is generated is stabilized, and generation of the image defect is restricted.

In this way, a length of a loop decreasing section is determined from a velocity and a timing at which a sheet P is conveyed. Further, the predetermined period of time Tout is determined as follows:

(1) It is supposed that a length, in the conveyance direction, of a sheet P preliminarily input into the operation portion **502** by a user, or sensed by a sheet regulation plate position or the like, not illustrated, of the sheet cassette **1** when the sheet P is loaded into the sheet cassette **1** is L.

(2) It is supposed that a distance from the secondary transfer portion **201**D to the registration roller **240** is E.

(3) It is supposed that among the pair of rollers that constitutes the fixing portion **201**E, the fixing roller **220***a* that receives and is driven by a driving force from the fixing motor M**4** has a circumference length Lr.

(4) The distances A, B, and C described above, and the length L, in the conveyance direction, of the sheet P are added together to become a value. From the value, the distance E, and a length that is the circumference length Lr multiplied by an integer N (N is an integer equal to or larger than one) are subtracted to determine a value. Then, the determined value is divided by the velocity Vs of the transfer belt **216** that has been set, to calculate a predetermined period of time Tout (Tout=(A+B+C+L−E−(N×Lr))/Vs).

Consequently, a rear end of a sheet P at a time of a lapse of the predetermined period of time Tout from a time of output of an exposure start signal is at a position (first position) that is upstream from the conveying nip portion of the registration roller **240**, by a length LA that is the circumference length Lr of the fixing roller **220***a* multiplied by an integer N (LA=N×Lr), as illustrated in FIG. **8**. By setting in this way, a distance conveyed at the velocity Vout that decreases a loop amount is made to be the circumference length Lr of the fixing roller **220***a* multiplied by an integer.

Note that in the image forming processing illustrated in FIGS. **4** and **5**, a unit that maintains a loop amount at a constant value by loop control is not limited to the loop detection portion **300**, but may be a prediction based on a conveyance distance, or the like.

FIG. **9** illustrates variations in loop amounts of sheets P at a time of changing a length of a loop decreasing section. In FIG. **9**, 1.0 on the horizontal axis indicating a conveyance distance indicates a position where conveyance is performed by a distance that is the circumference length Lr of the fixing roller **220***a* multiplied by an integer from 0.0 that is a position at a time of a lapse of a predetermined period of time Tout from a time of output of an exposure start signal (a time of a start of a loop decreasing section).

A rotational phase ψ of the fixing roller **220***a* that becomes the fixing nip portion at a time of a lapse of a predetermined period of time Tout from a time of output of an exposure start signal changes for every sheet P. Therefore, a variation width of a loop amount corresponding to a conveyance distance also varies for every sheet P.

On the other hand, if a distance across which a sheet P is conveyed at the velocity Vout is the circumference length Lr of the fixing roller **220***a* multiplied by an integer, a loop winding amount from a time of a start of a loop decreasing section to a rear end of the sheet P passing through the registration roller **240** is the same, irrespective of the rotational phase ψ, as illustrated in FIG. **9**. Here, the loop winding amount is an amount that decreases a loop amount. Therefore, to restrict conveyance variations due to rotational phases, a distance across which a sheet P is conveyed at the velocity Vout can be set to the circumference length Lr of the fixing roller **220***a* multiplied by an integer.

In the present embodiment, however, it is supposed that a realistic effect range of an allowed variation width of a loop amount that restricts generation of an image defect is a range that is the circumference length Lr of the fixing roller **220***a* multiplied by an integer N±25% (N±25%), as illustrated in FIG. **9**. Note that although it is supposed that the realistic effect range is ±25%, the realistic effect range is not limited to the range of the present embodiment if a distance across which a sheet P is conveyed at the velocity Vout is made closer to the circumference length Lr of the fixing roller **220***a* multiplied by an integer.

With reference to FIG. **5** again, next, the controller **400** determines whether or not a predetermined period of time Tout**2** has elapsed from the time of the output of the exposure start signal (S**16**). Here, a time of a lapse of the predetermined period of time Tout**2** from the time of the output of the exposure start signal is a point after the rear end of the sheet P passing through the registration roller **240**, and before the rear end of the sheet P passing through the secondary transfer portion **201**D.

In a case of before a lapse of the predetermined period of time Tout**2** (S**16**: No), the controller **400** repeats the processing of step S**16**.

On the other hand, if the predetermined period of time Tout**2** has elapsed (S**16**: Yes), the controller **400** changes a rotational speed of the fixing motor M**4** into a rotational speed Rout**2** stored in the ROM **401**. Consequently, the controller **400** switches the fixing conveyance velocity from the velocity Vout to a velocity Vout**2** (S**17**).

The velocity Vout**2** is a velocity slightly slower than the velocity Vs of the transfer belt **216** (Vout**2**<Vs), and is a velocity that can increase again a loop amount of a sheet P between the secondary transfer portion **201**D and the fixing portion **201**E. Consequently, after the rear end of the sheet P passes through the registration roller **240**, a loop amount of the sheet P is increased. Therefore, the sheet P is not excessively pulled by the fixing portion **201**E, and the secondary transfer image is not distorted.

Here, in a case of image formation of a color image, the predetermined period of time Tout**2** is calculated as follows: It is supposed that a distance from the secondary transfer portion **201**D to the registration roller **240** is E. Then, the distances A, B, and C described above, and a length L, in the conveyance direction, of a sheet P are added together to become a value. The value from which the distance E is subtracted is divided by the velocity Vs of the transfer belt **216** that has been set, to determine a predetermined period of time Tout**2** (Tout**2**=(A+B+C+L−E)/Vs). The distance E is stored in the RAM **402** in such a manner that the distance E can be changed as necessary.

Next, the controller **400** determines whether or not a predetermined period of time Tend has elapsed from the time of the output of the exposure start signal (S**18**). Here, a time of a lapse of the predetermined period of time Tend from the time of the output of the exposure start signal is a point after the rear end of the sheet P passing through the secondary transfer portion **201**D, and before the rear end of the sheet P passing through the fixing nip portion of the fixing portion **201**E.

In a case of before a lapse of the predetermined period of time Tend (S**18**: No), the controller **400** repeats the processing of step S**18**.

On the other hand, if the predetermined period of time Tend has elapsed (S**18**: Yes), the controller **400** switches the fixing conveyance velocity to the velocity Vm (S**19**).

Next, the controller **400** determines whether or not image formation is being performed (S**20**).

If image formation is being performed (S**20**: Yes), the controller **400** returns to the processing of step S**6**.

On the other hand, if image formation is not being performed (S**20**: No), the controller **400** determines that a sheet P on which an image has been formed at the end is a final image formation sheet, and ends image formation (S**21**). The final image formation sheet P is discharged into the discharge space S by the pair of first discharge rollers **225***a* or the pair of second discharge rollers **225***b*. At this time, the fixing conveyance velocity is not switched and remains at the above fixing conveyance velocity Vm, and rotation is performed until the sheet discharge sensor S**3** senses the discharge of the sheet.

Next the controller **400** stops rotation of the exposure motor M**1**, the conveying motor M**2**, the image formation motor M**3**, the fixing motor M**4**, and the sheet discharge motor M**5** through the driver **403** (S**22**), and ends the image forming processing.

In the present embodiment, when a rear end of a sheet P reaches a position that is upstream, in the conveyance direction, from the registration roller **240**, by a distance that is a circumference length of the fixing roller **220***a* multiplied by an integer, a conveyance velocity of the fixing portion **201**E is maintained at a constant velocity. Further, a loop amount of the sheet P is decreased compared with before a rear end of the sheet P reaches a position that is upstream, in the conveyance direction, from the registration roller **240**, by a distance that is a circumference length of the fixing roller **220***a* multiplied by an integer. Consequently, even if a diameter of the fixing roller **220***a* of the fixing portion **201**E varies according to rotational phases, a loop amount of a sheet P is stabilized, and generation of an image defect is restricted.

Second Embodiment

A configuration of an image forming apparatus according to a second embodiment of the present invention is the same as the configuration in FIGS. **1** to **3**B. Therefore, descriptions of the configuration of an image forming apparatus according to the second embodiment will be omitted.

<Image Forming Processing>

Image forming processing according to the second embodiment of the present invention will be described in detail with reference to FIG. **10**.

An only difference between the image forming processing according to the present embodiment and the image forming processing illustrated in FIGS. **4** and **5** is a setting of a section that increases a loop amount of a sheet P after a predetermined period of time Tout**2** elapses from a time of output of an exposure start signal (hereinafter, described as the "loop increasing section"). Therefore, descriptions except the loop increasing section are omitted in the present embodiment.

If a loop amount between the fixing portion **201**E and the secondary transfer portion **201**D is too small when a rear end of a sheet P passes through the secondary transfer portion **201**D, the sheet P is not along the transfer belt **216** at the rear end of the sheet P, and an image defect is generated. On the other hand, if a loop amount between the fixing portion **201**E and the secondary transfer portion **201**D is too large, an image defect, such as color misalignment, is generated. Therefore, a conveyance distance needs to be stabilized also for the loop increasing section.

Here, in the loop increasing section, it is difficult to sense a loop amount with a simple configuration, similarly as the loop decreasing section. Therefore, loop control is not performed, and the fixing roller **220***a* is driven and rotated at a rotational speed preliminarily stored in the ROM **401**.

Consequently, similarly as the loop decreasing section, a length of the loop increasing section is set to a circumference length of the fixing roller **220***a* multiplied by an integer. The length of the loop increasing section is determined from a velocity and a timing at which a sheet P is conveyed. Further, a predetermined period of time Tout**2** at this time is determined as follows:

(1) It is supposed that the fixing roller **220***a* that receives and is driven by a driving force from the fixing motor M**4** has a circumference length Lr.

(2) The distances A, B, and C described above, and a length L, in the conveyance direction, of a sheet P are added together to become a value. From the value, a length that is the circumference length Lr of the fixing roller **220***a* multiplied by an integer N is subtracted to determine a value. Then, the determined value is divided by the velocity Vs of the transfer belt **216** that has been set (Tout**2**=(A+B+C+L−(N×Lr))/Vs).

Consequently, a rear end of a sheet P at a time of a lapse of the predetermined period of time Tout**2** from a time of output of an exposure start signal is at a position (second position) that is upstream, in the conveyance direction, from the transfer nip portion of the secondary transfer portion **201**D, by a length LB that is the circumference length Lr of the fixing roller **220***a* multiplied by an integer N (LB=N×Lr), as illustrated in FIG. **10**. By setting in this way, a distance conveyed at the velocity Vout**2** that increases a loop amount is made to be the circumference length Lr of the fixing roller **220***a* multiplied by an integer. Therefore, generation of an image defect is restricted.

In the present embodiment, however, it is supposed that a realistic effect range of an allowed variation width of a loop amount that restricts generation of an image defect is a range that is the circumference length Lr of the fixing roller **220***a* multiplied by an integer ±25%, similarly as the first embodiment described above. Note that although it is supposed that the realistic effect range is ±25%, the realistic effect range is not limited to the range of the present embodiment if a distance across which a sheet P is conveyed at the velocity Vout**2** is made closer to the circumference length Lr of the fixing roller **220***a* multiplied by an integer.

Needless to say, the present invention is not limited to the embodiments described above, but may be variously modified without departing from the gist of the present invention.

More specifically, in the first and second embodiments described above, the conveying motor M**2** drives and rotates the fixing roller **220***a*. A motor driven and rotated by the conveying motor M**2** is not limited to this, but the conveying motor M2 may drive and rotate the heating roller **220***b*. In this case, distances conveyed at the velocity Vout that decreases a loop amount and at the velocity Vout2 that increases a loop amount are made to be a circumference length Lr of the heating roller **220***b* multiplied by an integer.

Further, in the first and second embodiments described above, a conveying roller is not provided between the registration roller **240** and the secondary transfer portion **201**D. The configuration is not limited to this, but a conveying roller as a conveying unit may be provided between the registration roller **240** and the secondary transfer portion **201**D. In this case, a loop amount of a sheet P is decreased when a rear end of the sheet P reaches a position that is upstream, in the conveyance direction, from the conveying roller between the registration roller **240** and the secondary transfer portion **201**D, by a distance that is a circumference length of the fixing roller **220***a* multiplied by an integer.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2020-162086, filed Sep. 28, 2020, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An image forming apparatus comprising:

a transfer unit that forms a transfer nip portion, and conveys a recording medium while transferring a toner image formed on an image bearing member;

a conveying unit that is provided upstream of the transfer unit in a conveyance direction of the recording medium, forms a conveying nip portion, and conveys the recording medium to the transfer unit;

a fixing unit that are included a heating rotating member and a pressure-applying rotating member that forms a fixing nip portion together with the heating rotating member, and conveys the recording medium while heating the toner image transferred to the recording medium by the transfer unit, at the fixing nip portion, to melt and fix the toner image on the recording medium; and

a control unit that controls a conveyance velocity of conveying the recording medium by the fixing unit, to form a loop in the recording medium between the transfer nip portion and the fixing nip portion,

wherein the control unit controls the conveyance velocity to decrease the loop when a rear end of the recording medium reaches a first position that is apart upstream, in the conveyance direction, from the conveying nip portion of the conveying unit, by a distance that corresponds to a circumference length of the pressure-applying rotating member multiplied by an integer.

2. The image forming apparatus according to claim **1**, further comprising

a loop detection unit that is provided between the transfer nip portion and the fixing nip portion, and detects an amount of the loop,

wherein before the rear end of the recording medium reaches the first position, the control unit controls the conveyance velocity in such a manner that the amount of the loop is within a predetermined range, on a basis of a detection result of the amount of the loop detected by the loop detection unit.

3. The image forming apparatus according to claim **2**, wherein

the conveyance velocity at a time of loop control by the loop detection unit is controlled at a first velocity (Vlow) and a second velocity (Vhigh) faster than the first velocity, and

after a rear end of the recording medium passes through the first position, the conveyance velocity decreases the loop at a third velocity (Vout) slower than the second velocity.

4. The image forming apparatus according to claim **1**, wherein

the control unit controls the conveyance velocity to increase the loop when the rear end reaches a second position that is apart upstream, in the conveyance direction, from the transfer nip portion of the transfer unit, by a distance that is the circumference length of the pressure-applying rotating member multiplied by an integer.

5. The image forming apparatus according to claim **4**, further comprising

a sensing unit that is provided upstream, in the conveyance direction, from the conveying unit, and senses the recording medium,

wherein the second position is a position of a rear end of a sheet being conveyed, at a time of a lapse of a predetermined period of time after the rear end of the sheet is sensed by the sensing unit.

6. The image forming apparatus according to claim **1**, wherein

the first position allows a dispersion of 25% to the circumference length of the pressure-applying rotating member multiplied by the integer.

* * * * *